ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

PROJECT NO. 34 - EVALUATION OF THE GUN FUME HAZARD IN THE LVT A-1

Project No. 34

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1 May 1944

ARMORED MEDICAL RESEARCH LABORATORY
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1. PROJECT: No. 34, Evaluation of the Gun Fume Hazard in the LVT A-1.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the extent of the hazard from gun fumes released by firing the 37 mm and turret .30 cal. machine gun in the LVT A-1.

2. DISCUSSION:

a. Methods and Conditions

(1) Fire Pattern

(a) 37 mm gun: The weapon was fired at the rate of one round every 5 seconds in bursts of 10, one burst being fired every 5 minutes.

(b) Machine Gun: The coaxial .30 cal. machine gun was fired at an average rate of 3000 rounds per hour. A 250 round belt was fired in approximately 4 minutes, allowing 1 minute for reloading.

(2) Ammunition: 37 mm; A.P.; M74. Machine Gun; caliber .30 ball.

(3) Tank Operation: Tests were carried out under 5 different operating conditions.

(a) Hatches closed, engine idling (800 rpm), no auxiliary ventilation (standard firing conditions). Tests were carried out with both the 37 mm and machine gun.

(b) Hatches closed, engine idling, auxiliary ventilation in turret (small centrifugal blower installed in rear of turret, exhausting 200 cfm). Tested with both 37 mm and .30 cal.

(c) Hatches closed, engine dead, no auxiliary ventilation. 37 mm and .30 cal.

(d) Hatches closed, engine dead, auxiliary ventilation in turret. 37 mm and .30 cal.

(e) Turret hatches open, engine idling, no auxiliary ventilation. 30 cal. only.

The pieces were fired at 12 o'clock with respect to the tank hull. Wind from 7 o'clock, 14 to 22 mph.

(4) Air samples were analyzed for carbon monoxide and ammonia by methods previously reported (Report on Project 3-1, 3-5, dated 15 Feb. 1943). In addition, continuous records of the carbon monoxide concentration at the loader's position were obtained with the Leeds & Northrup Selective Gas Analyzer. The detailed results of the tests are collected in the appendix.

2. CONCLUSIONS:

a. The highest concentrations of carbon monoxide were found in the turret. Considerably lower concentrations were measured in the hull and still lower in the driving compartment. No dangerous concentrations were found in either the hull or driving compartment during firing of the turret pieces.

b. Under almost every condition of test the machine gun produced higher concentrations of carbon monoxide in the turret than did the 37 mm gun.

c. With the standard conditions of 37 mm gun fire (engine idling, hatches closed) an average carbon monoxide concentration of 0.044% was produced at the loader's position. This is just within the limit of 0.05%, tolerable for one half ($\frac{1}{2}$) hour.

Under the same conditions, a concentration of 0.128% was present during firing of the machine gun. This is considerably in excess of the tolerable limit.

d. The additional ventilation provided by a simple exhaust fan in the turret reduced the carbon monoxide concentrations to levels only 1/10 as high as found without the fan. The average concentrations were less than 0.01% during firing of both the machine gun and 37 mm gun.

e. Firing with the engine dead and the hatches closed resulted in average carbon monoxide concentrations in the turret slightly less than half those found with engine running (0.019 for the 37 mm and 0.043 for the .30 cal.). This indicates as does study of the vehicle itself that the engine contributes but little to the ventilation of turret, and that a more positive means of turret ventilation is required.

f. Operation of the auxiliary turret fan with engine dead and buttoned up resulted in reduction of the average carbon monoxide concentration to insignificant levels during firing of both the 37 mm and machine gun.

g. When the machine gun was fired with engine idling and the turret hatches open insignificant amounts of carbon monoxide were found in the turret air.

3. RECOMMENDATIONS:

a. That an exhaust fan of approximately 200 cfm capacity be installed in the rear of the turret as shown in Fig. 2.

(NOTE: The conclusions and recommendations set forth above have been concurred in by Headquarters, Armored Center, W. H. Nutter, Colonel, G. S. C., Chief of Staff.)

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#1 - Appendix
#2 - Table 1
#3 - Fig. 1
#4 - Fig. 2

APPENDIX

RESULTS

The data are tabulated in Table 1, and the average concentrations of carbon monoxide found at the breathing zone of the loader are plotted in Fig. 1. It should be emphasized that the results found apply to the particular firing rates used. Higher firing rates would result in higher concentrations, the increase in the degree of exposure being roughly in proportion to the firing rate.

The results are quite clear-cut and do not require detailed discussion. Hull and driving compartment contamination was negligible. The machine gun was consistently the worst offender as a source of carbon monoxide. Lower concentrations were found with the engine dead than with it in operation. This was undoubtedly the result of the particular wind conditions at the time of the trial. It indicates that the operation of the engine provides little positive ventilation in the fighting compartment, a situation which is evident from a study of the vehicle itself. The air which is drawn from the hull through the oil cooling radiators in the bulkhead is readily supplied through the two large deck openings aft of the turret so that little positive draft is induced through the fighting compartment. There was no measureable pressure drop (by velometer) in the turret while the engine was idling. This lack of positive ventilation was further demonstrated by the persistence of carbon monoxide in the turret after firing, twenty (20) to thirty (30) seconds being required to reduce the concentration 50% (See Table 1). A necessary consequence of this situation is that the rate of effective turret ventilation is largely dependent upon the external conditions of wind velocity and direction, and the orientation of the turret with respect to the hull. It is probable that with a head wind, or with lower wind velocity than obtained during these tests that turret concentrations would be higher than those reported in these tests.

It is evident from the foregoing that a positive means of turret ventilation is required. As demonstrated by the tests, the ventilation of the turret can be easily improved by installation of an exhaust fan which, in these tests, reduced the CO concentrations to levels well below the tolerable limit. The capacity of the fan used was 200 cfm with a power consumption of 108 watts. By installing the fan in the turret no additional opening is required. Due to space limitation within the turret, the fan should be mounted outside, covered by armor and with bottom discharge, as shown in Fig 2.

Encl #1

TABLE 1

CONCENTRATIONS OF CARBON MONOXIDE
DURING THE FIRING OF THE TURRET WEAPONS
IN THE LVT A-1

CONDITIONS OF TEST			CARBON MONOXIDE Percent				CLEARANCE RATE
			Average Concentration			Peak Conc.	
Engine Speed rpm	Hatches	Fan	Loader	Hull	Driver	Loader	*Seconds
37 MM							
800	Closed	Off	.044 .043 s	.020	.017	.069 .128	22 - 30
800	Closed	On	.004 s	-	-	.005 .019	7 - 8
Dead	Closed	Off	.019 s	-	-	.074	21
Dead	Closed	On	.001 s	-	-	.001	6
MACHINE GUN							
800	Closed	Off	.128 .137 s	.025	.016	-	-
800	Closed	On	.008 s	-	-	-	-
Dead	Closed	Off	.043 s	-	-	-	-
Dead	Closed	On	.001 s	-	-	-	-
800	Turret open	Off	<. 01 s	-	-	-	-

The values followed by 's' were obtained with the L. and N. Selective Gas Analyzer; all others with glass sampling equipment and subsequent analysis.

* Time for concentration to decrease 50%.

Encl #2

FIG. 1

CARBON MONOXIDE CONCENTRATIONS RESULTING FROM FIRING THE TURRET WEAPONS IN THE LVT A-1

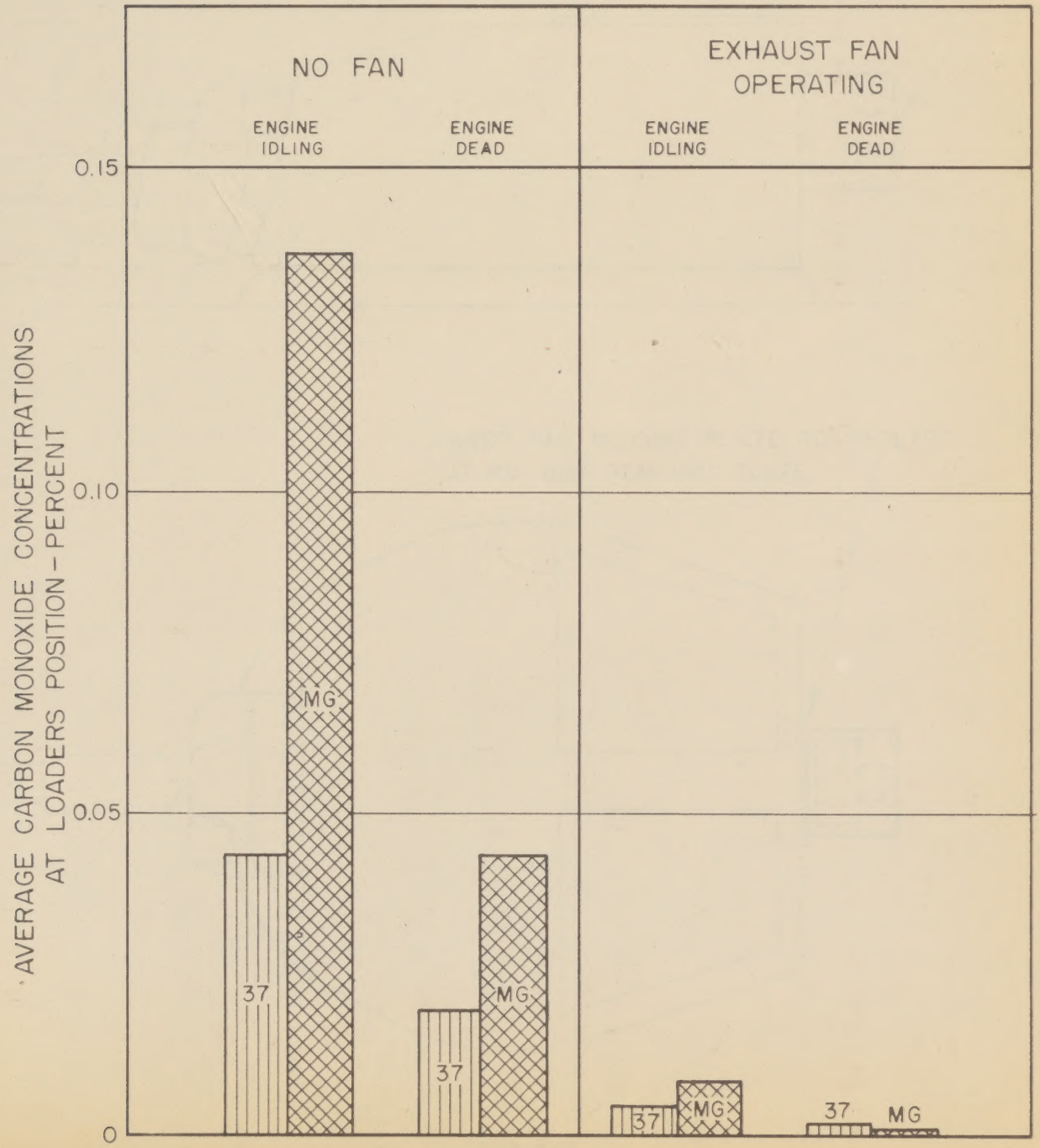
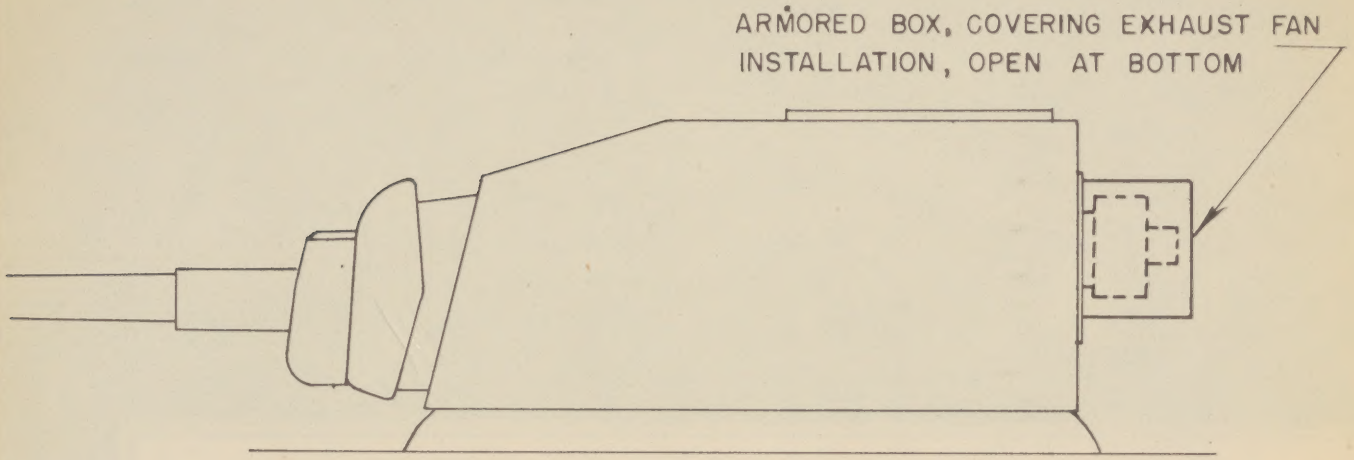


FIG. 1

FIG. 2

LOCATION OF EXHAUST FAN UNIT ON L.V.T. (A I)



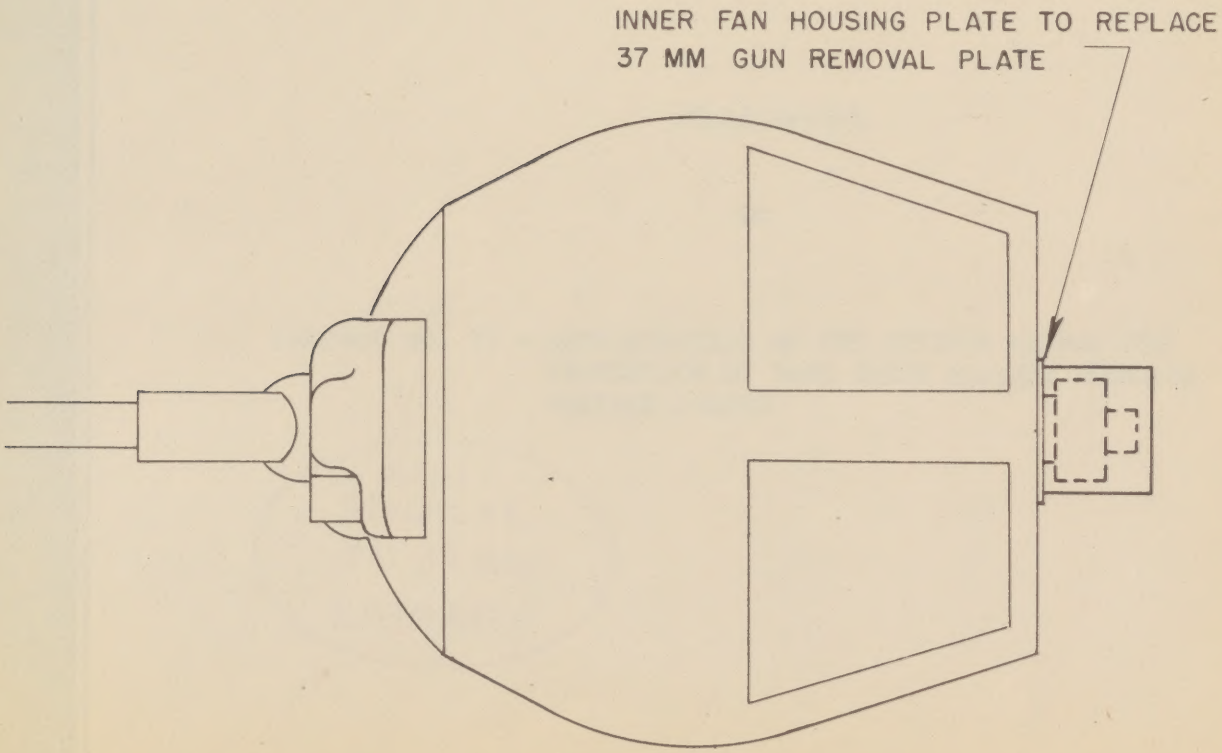


FIG. 2